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Agriculture

Anaerobic Pump

This invention uses a new process and hardware design for a more efficient two-stage digestion of wet-solid-organic wastes to produce a methane-CO_2 (biogas) mixture. The second stage of the process increases the kinetics. The unit produces three times the amount of methane per the amount of organic material fed to the unit. Residual disposal is virtually eliminated because it converts nearly all (~90%) the solid feed to methane and CO_2.

OIT Contact: **Lisa Barnett**

BEI Hydrolysis Process

The BEI Hydrolysis Process uses a double tubular reactor that is precisely controlled to convert cellulose into a high sugar content material. The second stage of the process also recovers heat and chemicals that can be reused in the first stage, thereby providing energy and economic savings. The process hydrolyzes cellulose to pentose, hexose, or glucose sugars at the point of use. These sugars may then be yeast-fermented to ethanol or other organic chemicals as commercial products.

OIT Contact: **Lisa Barnett**

Biofine Technology

Using the Biofine Technology, low-grade waste-cellulosic by-products from paper mills, municipal solid waste plants, and other sources can be converted into levulinic acid, a versatile chemical that is an intermediary to several other products. The conversion of cellulose to levulinic acid is accomplished via high-temperature, dilute-acid hydrolysis in a novel reactor configuration.

OIT Contact: **Mark Paster**

Agriculture
(continued)

Novel Membrane-Based Process for Producing Lactate Esters

This research aims to develop nontoxic replacements for halogenated and toxic solvents. The new method uses proprietary advanced fermentation, membrane separation, and chemical conversion technologies to covert renewable carbohydrate feedstocks into lactate esters in an energy-efficient and cost-effective way.

OIT Contact: **Charlie Russomanno**

Plastics, Fibers, and Solvents from Biosynthetically Derived Organic Acids

Biologically-derived succinic acid is produced by fermenting glucose sugar from corn. After separation and purification, the succinic acid is used as a chemical intermediate that is converted into chemical feedstocks. The feedstocks are then used to make a wide assortment of products such as plastics for automobiles and household items, fibers for clothing, food additives, and solvents for paints and paint removers.

OIT Contact: **Mark Paster**

Sensor System to Monitor Gaseous Nitrogen Transfer

An integrated-optics (IO) sensor system that can monitor and measure ammonia concentrations in the range of 100 parts-per-billion and above is being commercialized in a different form. A form of this sensor for water monitoring is under development. It can look for ammonia content in water for the purposes of environmental, agricultural runoff monitoring and wastewater monitoring.

OIT Contact: **Brian Valentine**

Soy-Based 2-Cycle Engine Oils

A new soy-based lubricant is being extensively field tested. This lubricant would replace petroleum or synthetic oils used in 2-cycle marine engines for motorboats and personal watercraft. The new product is 90% to 100% biodegradable, produces fewer emissions, and extends engine life.

OIT Contact: **Mark Paster**

Agriculture
(continued)

◆ Utilization of Corn-Based Polymers

Each year, 60 billion pounds of thermoplastics are produced from imported and domestic oil to make industrial and consumer products. Researchers are exploring ways to modify the chemical structure of polylactic acid, a corn-based polymer, to enable its use in place of thermoplastics in numerous applications. Substituting corn for petroleum will use 20% to 50% less fossil resources than conventional plastics and will emit less CO_2 compared with other petroleum-based thermoplastics. Projections are that 10% of the U.S. nonrenewable plastics packaging can be replaced with polylactic acid.

OIT Contact: **Mark Paster**

Aluminum

◆ Aluminum Salt Cake: Electrodialysis Processing of Brine

This project aims to eliminate landfilling of aluminum salt cake by developing technologies that will separate salt cake into constituents (aluminum, salt, and nonmetallic products). Salt recovery consumes more energy and incurs more costs than any other unit operation in the recovery of salt cake constituents. If successful, an OIT-sponsored salt-recovery process based on electrodialysis will be more cost-effective than the established technology (evaporation with vapor recompression).

OIT Contact: **Charlie Russomanno**

◆ Aluminum Scrap Sorting

This particle-sorting technology focuses on demonstrating the capability to sort nonferrous metal scrap from the reusable materials from aluminum-intensive vehicles. The process includes physical property sorting and chemical composition sorting and is capable of real-time, piece-by-piece batching of specific alloy compositions from the analyzed scrap. This process will help improve the melt composition of recycled materials and is more efficient and less energy intensive than existing chlorination, fractional solidification, and electro-refining processes.

OIT Contact: **Sara Dillich**

◆ Brazing and Spot Welding for Joining Al Alloys in Vehicle Manufacturing

This technology will have immediate applications with bonding aluminum in various end-use industries, including the automotive and heat exchanger industries.

OIT Contact: **Lisa Barnett**

Aluminum
(continued)

◆ Converting Spent Potliner to Products

A new technology, the cyclone melting system, is being developed that will convert spent potliner from aluminum smelting plants into commercial-quality glass fiber and aluminum fluoride products. Spent potliner contains many of the chemical oxides typically used to manufacture glass products. The benefits of this new technology are the ability to produce a value-added product from the waste, to recover fluoride from the waste in a form that can be recycled back into the aluminum production process, and to reduce waste disposal costs.

OIT Contact: **Sara Dillich**

◆ Improved Grain-Refinement Process

A new method of grain refining aluminum, called the fy-Gem process, has been demonstrated to be an effective way to refine aluminum castings. This invention offers significant cost, energy, and environmental benefits and addresses the important issue of how to produce ingots of higher quality, particularly with respect to boride inclusion. The fy-Gem process addresses the problems and costs associated with the use of titanium and boron in grain refiners and is likely to result in cleaner, higher quality castings.

OIT Contact: **Sara Dillich**

◆ Improved Methods to Manufacture Carbon-Alumina Composite Anodes for Al Reduction

An improved composite anode for electrochemically reducing aluminum was developed with an Inventions and Innovation grant. The sandwich design obviates the need for using electrolytes that have melting points sufficiently high to dissolve alumina and makes it possible to operate the cell at a lower temperature. The process produces oxygen instead of carbon dioxide and perfluorocarbon emissions.

OIT Contact: **Lisa Barnett**

Aluminum
(continued)

◆ Microsmooth Process on Aluminum Wheels

This new process is an innovative electroless nickel-plating technology that improves aluminum-chromium plating quality while substantially reducing electric and natural gas usage. The new process will lower production costs and eliminate the use of zincate and the wastes associated with the traditional plating process.

OIT Contact: **Lisa Barnett**

◆ Molten Aluminum Explosion Prevention

Research underway will improve industry's understanding of the conditions that trigger aluminum-water explosions, as well as the reasons and extent to which certain coatings prevent those explosions. One result of the research will be a basic understanding of the entrapment of heat over submerged coated and uncoated surfaces.

OIT Contact: **Ramesh Jain**

◆ Novel Technique for Increasing Corrosion Resistance of Aluminum and Aluminum Alloys

A new process imparts a corrosion-resistant coating to aluminum and aluminum alloys. The process uses nontoxic lithium and magnesium salts, with or without heat treatment, to replace the currently used hexavalent chromium, which is known to be a highly toxic carcinogen.

OIT Contact: **Lisa Barnett**

◆ Vertical Flotation Melter

The Vertical Flotation Melter (VFM) is an advanced remelting process that is energy efficient and environmentally friendly. It will help the aluminum industry meet energy and environmental performance targets. The technology also applies to other industries, such as the glass container, fiberglass and steel industries.

OIT Contact: **Ramesh Jain**

Chemicals

Alloys for Ethylene Production

New intermetallic or metallic alloys are being developed for manufacturing ethylene production tubes that are resistant to coking and carburization. Traditionally, ethylene furnace tubes have been fabricated from cast or wrought high stainless steel alloys. Coke and metal carbide layers form on the inside surfaces of the tubes, reducing the mass flow and heat transfer of the tubes and resulting in significant downtimes. The new material will reduce these problems as well as increase the structural life of the tubes.

OIT Contact: **Paul Scheihing**

Catalytic Hydrogenation Retrofit Reactor

A new monolith loop reactor, a compact fixed-bed catalyst system, is being developed for use in a variety of hydrogenation chemical processes. This technology integrates new catalyst chemistry with advances in reaction engineering and can be retrofitted onto existing slurry tank reactor systems. The technology replaces slurry catalysts and their associated problems. Target markets include the specialty chemical, fine chemical, and pharmaceutical industries. This new technology provides a number of benefits to these industries: reduced energy consumption because of higher productivity and improved yields new synthesis pathways to reduce waste and eliminate solvents in some systems, and decreased energy consumption associated with distillation.

OIT Contact: **Brian Valentine**

Concurrent Distillation

This project aims to improve the performance of high-pressure distillation trays by using a con-current flow design and to establish the economics of the process. The research will provide the design information and performance correlations necessary to manufacture the "Trutna Tray" (Co-Flo™). During the course of the project, the tray is being pilot tested in an industrial application.

OIT Contact: **Brian Valentine**

Chemicals
(continued)

Electrodeionization for Product Purification

This technology combines the advantages of ion exchange (an adsorption technology) with those of electrodialysis (a membrane separation) for a wide range of potential applications in the chemical industry, including product purification, waste recovery, and water recycling. Targeted applications include removing catalysts from process streams, polishing products, and recovering waste salt.

OIT Contact: **Charlie Russomanno**

Low-Cost, Robust Ceramic Membranes for Gas Separation

Ceramic membranes offer great potential for industrial gas separation. Unfortunately, even though ceramic membranes can improve the productivity for many reactions and separations in the chemicals and refining industries, they are costly. This new technology has overcome the cost barrier through the use of a low-cost, robust ceramic membrane with applications targeted toward hydrogen production, landfill gas recovery (methane), and CO_2 removal in natural gas processing. Significant energy savings are possible because cooling prior to gas separation can be eliminated.

OIT Contact: **Paul Scheihing**

Low-Frequency Sonic Mixing Technology

This technology is an energy-efficient, electromechanical system that effectively substitutes low-frequency sonic energy for chemical and mechanical mixing, significantly improving the manufacture of a broad range of industrial products. This simple yet effective technology transfers acoustic energy into liquid and slurry systems, inducing two important phenomena in fluids: cavitation and acoustic streaming. The result is improved chemical reaction and leaching processes and increased mixing and mass transport.

OIT Contact: **Lisa Barnett**

Chemicals
(continued)

◆ Membrane for Olefin Recovery
Selective polymer membranes are being developed to allow recovery of olefins (compounds with carbon-carbon double bonds such as ethylene and propylene) from petrochemical by-product and vent streams. These streams are often flared or used as a fuel even though the olefin is more valuable as a chemical feedstock. This new separation technology will allow olefin separation and recycling within the process.

OIT Contact: **Paul Scheihing**

◆ No-VOC Coating Technologies
The project is to demonstrate the commercial viability of a coating with no volatile organic carbons (VOCs) that prevents harmful emissions and liquid waste without the need for add-on controls. Water-based coatings will be used on metal instead of the traditional VOC coatings, thus saving energy used in the drying process as well as reducing the environmental impacts.

OIT Contact: **Lisa Barnett**

◆ Nylon Carpet Recycling
This new chemical process provides recycled materials for manufacturing carpet products. The process can be used to recycle the used nylon carpet currently sent to landfills each year. The technology allows nylon manufacturers to recover and reuse caprolactam, the raw material used to make nylon 6 for carpets. A fully operating recycling plant is expected to keep more than 200 million pounds of post-consumer carpet waste out of U.S. landfills and produce approximately 100 million pounds of new caprolactam each year.

OIT Contact: **Charlie Russomanno**

◆ Plastic Foam and Film Recovery Through Thermal Densification
A new high-throughput densifier being demonstrated for industrial plastic foam and film allows recovery of foam and film excesses. Ground foam is introduced into an air stream that enters a heated chamber where it is melted into pellets. The output can be used directly in the manufacturing process or densified for reuse or sale as a commodity.

OIT Contact: **Lisa Barnett**

Chemicals
(continued)

◆ Pressure Swing Adsorption for Product Recovery
Recovery of hydrogen from refinery offgas for reuse as a higher value product or recovery of olefins from polyolefin plant vent gases are opportunities for providing increased productivity, energy savings and reduced waste. Pressure swing adsorption (PSA) is an energy-efficient and economical method for recovering these components in a single unit operation.

OIT Contact: **Charlie Russomanno**

◆ Recovery of Thermoplastics via Froth Flotation
A technique is under development to separate high-value plastics from plastic waste streams, which then can be recycled and reused. Current methods for separating plastics cannot economically remove plastics of identical or similar density from each other. In bench-scale testing, the froth-flotation process for separating plastics has successfully recovered ABS and HIPS plastics with a purity of more than 99% and a yield of higher than 80%. There are significant benefits due to lower energy use and resource conservation in the reuse of plastics for industrial manufacturing.

OIT Contact: **Charlie Russomanno**

◆ Separation of Recovered Plastics
A new technology is being demonstrated that allows plastics of similar densities to be separated for reuse. If successful, then plastics could be recovered from post-consumer durable goods and recycled back to the appliance industry, thus closing the plastics-recycle loop.

OIT Contact: **Lisa Barnett**

◆ Sorbents for Gas Separation
A new technology based on oxygen-selective sorbent materials and pressure swing adsorption (PSA) could cost-effectively produce industrial gases, such as oxygen and nitrogen. Purification applications where oxygen is removed from argon, helium, and nitrogen streams offer early potential commercial opportunities. This technology potentially requires less energy for gas separation compared to conventional techniques and can provide high-purity gases at lower cost.

OIT Contact: **Charlie Russomanno**

Chemicals
(continued)

Supercritical Purification of Compounds Used for Combinatorial Chemical Analyses

This innovative approach to combinatorial chemistry, supercritical fluid chromatography, analyzes samples 20 to 100 times faster than current liquid chromatography technology and greatly reduces waste and energy use. Conventional systems can purify only 5 to 10 compounds/day and require several manual operations, two to three trial runs, and up to 48 hours for final purification. The automated supercritical fluid chromatograph can purify 100 to 200 compounds/day/machine and requires just 2% of the energy required by a conventional system.

OIT Contact: **Lisa Barnett**

Total Cost Assessment Tool

In traditional chemicals industry decision-making, environmental health and safety assessments have been conducted separately from life-cycle cost analyses. This customary separation has limited the influence and relevance of life-cycle assessment for decision-making and has left the important relationships and tradeoffs between the economic and environmental performance of alternative decisions uncharacterized. A new software tool is being developed that uses total cost assessment methodology to improve investment decision-making. This new tool can integrate environmental life-cycle assessment and scenario-based risk analysis to provide a complete description of all potential environmental health and safety related costs associated with a process or product.

OIT Contact: **Brian Valentine**

Forest Products

Acoustic Humidity Sensor

This project is building and testing a prototype humidity sensor that is integrated into a humidity control system that measures and corrects the humidity in a paper dryer. This invention works by sending a sound pulse through the air in the paper dryer and comparing it to a sound pulsed through a closed dry air tube at the same temperature. By allowing the dryer to operate at the lowest temperature possible, the sensor can greatly reduce energy consumption while avoiding condensation problems that are caused when the temperature is too low.

OIT Contact: **Lisa Barnett**

Acoustic Separation Technology

This technology uses acoustic radiation pressure (ARP) to separate different fibers in suspension. This is key in pulp compaction, fiber deflection, and separation and is much easier to control than pressure-screen systems. There have been a number of applications identified for this technology, including fiber-fractionation, separation, pulp thickening, and removal of undesirable particles in closed water systems.

OIT Contact: **Valri Robinson**

Christian Veneer Dryer

This invention offers great advantages over conventional veneer drying systems, including energy savings and reducing damage to veneer sheets. Instead of blowing and then exhausting very hot air across a conveyor line of veneer, the green veneer sheets are placed in individual slots within a closed rotating drum. Natural gas or cogeneration heat drives moisture out of the veneer, and the moisture and some pollutants are condensed on cooling coils.

OIT Contact: **Lisa Barnett**

Forest Products
(continued)

◆ Contactless Real-Time Monitoring of Paper Mechanical Behavior During Papermaking

This technology uses real-time noncontact laser ultrasonics to monitor different paper mechanical properties (e.g., bending, stiffness, and shear rigidity) during the papermaking process. Current methods to probe paper mechanical properties use transducers in direct contact with the web. This approach is not desirable because contact transducers can potentially damage the web, leading to costly production losses. Also, these transducers are not designed to operate with fine papers such as copy paper, thereby limiting their range of application to paperboards. Contactless real-time monitoring will reduce waste and energy use through less refining and remanufacturing, optimal use of pulp feedstock, and reduced production of off-grade paper.

OIT Contact: **Valri Robinson**

◆ Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers

A sensing system is being developed to detect deposits on the pendant tubes of Kraft chemical recovery boilers and to demonstrate the system's usefulness in extending the time between boiler shutdowns by ameliorating other deposit-related problems. The method directly monitors deposition of fume and carryover particles on recovery boiler pendant tubes. This information is used in conjunction with simultaneous gas temperature measurements to develop an effective plug control scheme for these deposits in Kraft boilers.

OIT Contact: **Lisa Barnett**

◆ KTM Logger

A mobile biomass densification unit has been produced that will be deployed in the agricultural fields and forests of California to combat wood burning in open fields. The machine turns the waste into sawdust, then immediately compacts it into logs. Since it is mobile, it can economically access waste and box it at location, making shipping costs substantially lower than shipping the waste in bulk.

OIT Contact: **Lisa Barnett**

Forest Products
(continued)

◆ Linear Corrugating

A new method of producing corrugated boxes was developed and demonstrated. The linear corrugating process changes the orientation between wood fibers and the corrugation, or flutes, in finished box production. Aligning the flutes parallel to the wood fibers causes the flutes to reinforce and strengthen the wood fiber. This results in a reduction of 25% in the amount of wood fiber while maintaining the crush strength of boxes.

OIT Contact: **Lisa Barnett**

◆ Long Wavelength Catalytic Infrared Drying System

A new drying system is being demonstrated that dehydrates wood chips and fines prior to oriented Strand board construction. This infrared technology reduces the moisture content by transferring energy directly to the moisture instead of heating the air and surrounding metal structure. The result is reduced energy and air emissions and improved productivity.

OIT Contact: **Lisa Barnett**

◆ Low-Emission Drying of Lumber and Wood Panel Products

This project is building and testing a pilot-scale pretreatment unit that extracts and collects volatile organic compounds (VOCs) from green softwood before it is dried. Brief treatment of softwood lumber under low headspace with radio frequency or steam removes over 70% of the VOCs (principally terpenes), which can be condensed and recovered. The process simultaneously reduces the need for VOC controls during wood drying (currently an energy- and capital-intensive process) and recovers a saleable chemical feedstock.

OIT Contact: **Valri Robinson**

Forest Products
(continued)

◆ Low Temperature Plasma Technology for Treating VOC Emissions

Pulp mills and wood product plants are under increasing pressure to control the emissions of volatile organic compounds (VOCs) generated during their operations. The present-day control technology - regenerative thermal oxidizers - is energy-intensive and depends on combustion technologies that heat the entire waste stream. An emerging technology using nonthermal plasmas can selectively and cost effectively destroy VOCs by producing excited species (free radicals and ions) that oxidize, reduce, or decompose pollutant molecules.

OIT Contact: **Valri Robinson**

◆ Lumber-Defect Detection System

An ultrasonic lumber inspection system is being demonstrated that scans green wood to determine if moisture levels are normal or if defects, such as "wetwood," are present. Before using this innovative method to separate the wood, processors would slow the dry kiln process to accommodate the defective wood, thus reducing production at the mill. By removing the defective wood to be dried separately, the unaffected wood can be dried at an accelerated rate, thus saving energy and reducing emissions in the kiln process.

OIT Contact: **Lisa Barnett**

◆ Online Fluidics Controlled Headbox

This technology strengthens paper fiber while lowering the energy costs of manufacturing it. The device, which is retrofitted into an existing paper machine's headbox, disperses wood fibers in all directions. This produces stronger paper and tremendously reduces the raw materials used.

OIT Contact: **Valri Robinson**

Forest Products
(continued)

◆ Online Paper Sensor

An improved sensor system for the paper industry has been developed and demonstrated. WebSense™ is an online system for measuring the uniformity of paper and its basis weight. Existing paper-web sensors that are commercially available acquire point measurements as they are periodically scanned across the web. Consequently, only a small fraction of the web area is measured. WebSense™ will provide continuous measurements across the entire web by measuring nearly 100% of the web area, thereby allowing improvements in process control and higher quality paper products.

OIT Contact: **Valri Robinson**

◆ Replacing Chemicals in Recycle Mills with Mechanical Alternatives

In recycling paper, "stickies" cause considerable downtime and require costly minerals and polymers to be added for handling and detackifying them during the recycling process. A new mechanical method - pulsed power technology - is being demonstrated at several recycling mills to replace these costly chemicals. This technology uses a shock wave, developed from a spark discharging under water, to diffuse the stickies and create hydroxyl radicals from water, which oxidizes the stickies. This oxidation causes the stickies to lose their tack and become benign, thus allowing recycling to continue unimpeded.

OIT Contact: **Valri Robinson**

Glass

◆ Advanced Combustion Space Model for Glass Melting

Improved understanding and modeling of the combustion process in glass melting will result in innovative furnace designs that will have higher combustion and furnace efficiencies, minimized pollutant formation (primarily NO_X reduction), and improved glass quality.

OIT Contact: **Elliott Levine**

◆ Advanced Low-E Coatings

Optically transparent coatings applied to float-glass, when used for windows in residential and commercial buildings, can substantially increase energy efficiency by rejecting heat in the summer and retaining it in the winter. These coatings are deposited using chemical vapor deposition methods, in which reactive gases flow over the hot glass as it exits the float bath. The new float-glass coatings are projected to save 1.4 X 1013 Btu per year when installed in place of clear glass windows.

OIT Contact: **Charles Sorrell**

◆ Coupled Combustion Simulation

One of the greatest obstacles to improving energy efficiency in the glassmaking industry is the inability to regulate heat flux distribution on the batch and glass melt surfaces. Heat flux distribution directly influences product quality, production time, and energy efficiency because it impacts melt recirculation patterns, batch chemical reactions, and residence time. This project is developing, validating, and applying three-dimensional combustion space/melt tank/batch melting models using real-world furnace data and conditions. The models will allow manufacturers to evaluate new furnace concepts fully and cost-effectively.

OIT Contact: **Elliot Levine**

Glass
(continued)

◆ Electrostatic Batch Preheater System

The electrostatic batch preheater system is a single-box solution that directs glass furnace exhaust gases through open-bottomed tubes running through a batch/cullet hopper. Direct contact with the hot exhaust gases preheats the batch and cullet before they enter the furnace and cleans SO_X from the exhaust gas stream. A proprietary electrostatic mechanism captures entrained dust and returns it to the batch. The technology reduces furnace fuel requirements by 10% to 15% and cleans the exhaust gas stream of NO_X and dust in accordance with the most stringent regulatory standards.

OIT Contact: **Elliot Levine**

◆ Enabling Tool for Innovative Glass Applications

Flat architectural and automotive glasses have traditionally been fabricated using technologies that have inherent cutting limitations because they are generally incapable of fabricating glass products with small radii, concave edges, or pierced holes. A new technology uses waste glass as a low-cost media for abrasive water-jet cutting of glass and other materials. This technology can refine and automate the glass manufacturing process while reducing the number of stages and equipment required to produce intricate glass products.

OIT Contact: **Lisa Barnett**

◆ Energy Efficient, Electric Rotary Furnace for Glass Molding of Precision Optical Blanks

Glass for optical blanks is heated to its softening point and pressed in a mold. This new technology, using electric heating, measures and controls this process precisely. Since electric heating requires no stack, the technology saves the 93% heat lost in the exhaust stack of gas-fired furnaces conventionally used in this industrial segment.

OIT Contact: **Lisa Barnett**

Glass
(continued)

◆ Glass Fiber Manufacturing

This project is to engineer, construct, and operate a prototype unit to demonstrate the complete feasibility of the technology and to measure the benefits. The new technology uses a resolving, doughnut-shaped melter that distributes the molten glass to a large number of bushings around its circumference. The internal burners use a mixture of gas and oxygen to produce a very uniform, energy-efficient melting temperature. This new furnace will be smaller than the current rectangular melters, but will produce the same capacity, thereby reducing energy used and capital-investment costs.

OIT Contact: **Lisa Barnett**

◆ High Luminosity, Low-NO_x Burner

This innovative burner increases luminosity and radiant heat transfer in high-temperature glass furnaces by modifying the fuel prior to combustion and then forming and burning soot in the flame. Increasing heat transfer rates while decreasing flame temperatures results in increased furnace production rates and thermal efficiency. This novel burner can be used in all existing and new oxyfuel glass melters.

OIT Contact: **Elliot Levine**

◆ High Throughput Vacuum Processing for Innovative Uses of Glass

This project is developing a manufacturing process for cadmium telluride photovoltaic solar cells. The innovative process uses a proprietary air-to-vacuum-to-air system that allows continuous production of cadmium telluride cells rather than the slower batch process. In addition, maintenance and labor costs are lower and occupational safety is improved.

OIT Contact: **Lisa Barnett**

Glass
(continued)

◆ Integrated Batch and Cullet Preheat for Glass Furnaces

This research is to commercially demonstrate a Raining Bed preheater technology using integrated batch and cullet to improve the overall economics of oxyfuel glass melting. The preheater is a heat- exchange system that preheats the glass furnace charge with hot flue gases. The recovered energy allows glass producers to reduce furnace utility operating costs for fuel and oxygen or boost furnace production, thus reducing the unit capital cost of producing glass.

OIT Contact: **Rolf Butters**

◆ Manufacturing Ceramic Products from Waste Glass

Ceramic products have traditionally been created using raw materials that require high firing temperatures and energy-intensive processing steps. A new technology is being developed that has the potential to lower energy costs by substituting raw materials with recycled waste glass. Products created using this new method are less sensitive to contaminants in the glass and can be made from difficult-to-recycle green or mixed-color waste glass. Firing temperatures can be reduced by as much as 37%, reducing energy needs and increasing recycling rates.

OIT Contact: **Lisa Barnett**

◆ Single Chip Color Sensor

This project involves developing a unique, affordable, color-classification sensor integrated with a data preprocessor on a single compact microchip. This robust, one-chip design offers accurate, real-time inspection that can improve production efficiency, reduce waste, and save energy in glass recycling The technology may also be used in other applications that monitor the detection of defects, such as crack detection in glass containers.

OIT Contact: **Rolf Butters**

Metal Casting

Highly Efficient Rapid Tooling Using Optimized Cooling Passages

A new rapid-prototyping process is being tested that improves investment-casting technology. Unlike conventional tooling processes, this new process more quickly and efficiently produces optimized cooling lines in all tooling shapes and sizes, increasing thermal efficiency and leading to better cycle times and increased productivity. This technology has applications in the die casting and permanent mold casting industries, where problems associated with poor thermal conductivity in materials are a concern.

OIT Contact: **Lisa Barnett**

Intelligent Control of the Cupola Furnace

This project involves designing and constructing a controller for the cupola process using intelligent (neural network) and conventional control methods. The use of a real-time control system to operate the cupola furnace will result in greater efficiency. Improved control will reduce material and processing costs, reduce scrap, and improve product quality.

OIT Contact: **Harvey Wong**

Lost Foam Casting Technology

Lost foam casting is a highly flexible process suitable for casting metal components with complex geometries. Research supported by OIT has led to a greater understanding of the process and to new control measures. These will increase foundry energy efficient and reduce scrap. Emerging technologies from the OIT-supported research include: in-plant quality assurance procedures to measure casting parameters; a sand-density gauge to measure the rate of sand compaction; and vibrational analysis instrumentation which, when coupled with the density gauge, allows the compaction cycle to be optimized to reduce compaction time and pattern distortion.

OIT Contact: **Harvey Wong**

Metal Casting
(continued)

Process to Recover and Reuse Sulfur Dioxide in Metal Casting Operations

Sulfur dioxide (SO_X) is used as a catalyst in forming cold-box molds and cores in the metalcasting industry. The SO_X is typically used once, scrubbed with a caustic solution, and then discarded (flushed to sewer or sent to a waste treatment facility). This new process recovers the SO_X for reuse by processing it through a pressure-swing absorber that is expected to recover at least 95% of the SO_X. Using this process will reduce energy consumption, eliminate the need for caustic effluent, and pay back costs in less than 1 year.

OIT Contact: **Lisa Barnett**

Rapid Heat Treatment of Cast Aluminum Parts

A system that reduces 90% of the time and energy required to heat-treat cast aluminum components is now being demonstrated. Unlike existing technologies where components are stacked in baskets and placed in a convection or vacuum furnace, this new process uses a fluidized bed in a continuous process mode. The fluidized bed is coupled to an automated production line that moves the components through the process. Pulse-fired microprocessor-controlled burners inject heat directly into submerged radiant burner tubes, ensuring precise, even, and rapid heat transfer.

OIT Contact: **Lisa Barnett**

Three-Dimensional Objects by Photosolidification

A fully automated prototype to aid in improving future design and confirming product validity and small-volume production has been developed and is in the early stages of commercialization. The system fabricates parts by imaging whole layers of liquid simultaneously and attaching one on top of another. Imaging is accomplished by flooding irradiation through a mask or negative in contact with the liquid, yielding parts that require no post cure. The system offers substantial reductions in both engineering design time and time for new product development, which will eventually allow prototype-manufacturing time to go from months to weeks.

OIT Contact: **Lisa Barnett**

Metal Casting
(continued)

Titanium Matrix Composite Tooling Material for Aluminum Die Castings

In the aluminum diecasting process, H-13 steel shot sleeves force molten aluminum into a die for casting. However, the conventional shot sleeve wears out after 20,000 to 40,000 casting cycles because of hot corrosion, which washes out the bottom of the sleeve. A new titanium-alloy composite material has a significant advantage over conventional technology because of its resistance to aluminum soldering and erosion. The material, CermeTi®, can be implemented as an entire shot sleeve or as a partial liner inserted into an existing H-13 shot sleeve.

OIT Contact: **Lisa Barnett**

Mining

Dense-Medium Cyclone Optimization

Dense-medium cyclones are used to separate coal or other minerals from waste rock in most modern coal plants and in a variety of mineral plants, including iron ore, diamonds, and potash. A set of engineering tools to improve the efficiency of dense-medium cyclones is being developed and demonstrated. These tools include low-cost density tracers to rapidly assess cyclone performance, mathematical process models to predict the effects of operating and design variables, and a model-based expert system for trouble-shooting cyclone circuits. These tools will successfully improve plant productivity, reduce energy costs, and minimize waste rock generation.

OIT Contact: **Mike Canty**

Grinding-Mill Optimization Software

A three-dimensional model for simulating semiautogenous grinding mills has been verified for use in mill operations. As a result of this new process simulation model, new grinding mill lifter designs are being incorporated into milling processes. Cost savings of nearly $4 million per year are expected with energy savings of approximately 30% expected in energy-intensive grinding-mill operations.

OIT Contact: **Arlene Anderson**

Imaging Ahead of Mining

An improved radio-imaging method that detects and maps anomalous geologic conditions far in advance of the mining face has been developed. Data from this new radio-imaging method will be analyzed by new full-wave imaging software to increase the capability of the sensor to avoid areas that should not be mined. The capability of this technology to reduce the amount of waste mined and increase productivity is being tested in commercial mines.

OIT Contact: **Arlene Anderson**

Mining
(continued)

◆ Magnetic Elutriation Technology for Processing Iron Ore

Magnetic elutriation improves the quality of low-grade domestic iron ore by using an alternating-current pulsed-magnetic field to clean iron ore into a highly refined product. This new continuous countercurrent system is being demonstrated in the field. The technology efficiently separates the tailings and middling particles out of the iron ore without using harmful chemicals.

OIT Contact: **Lisa Barnett**

◆ Mapping with Natural Induced Polarization

Natural field-induced polarization uses natural electromagnetic fields as the source to collect induced polarization data. The mining industry uses induced polarization surveys to locate and characterize mineral resources. Conventional surveys use high-power motor-generator sets to transmit electrical current in the earth through grounded electrodes that are slow and laborious to install. This new noninvasive technique eliminates the need for the electrodes and the motor-generator sets and provides greater depth of exploration than conventional surveys. These reduced drilling requirements reduce energy and environmental impacts.

OIT Contact: **Arlene Anderson**

◆ On-Board Intelligent Lubrication Prognostic *(Oil Pro)* System

Automated machine fluid analysis allows rapid determination of oxidation, wear metals, and contamination by particulates or coolant in lubricants. In the on-vehicle configuration, the system provides near-real-time status of machine fluids and can alert the operator immediately if lubricant degradation exceeds preset limit values. In the onsite configuration, multiple samples from different vehicles or machines can be analyzed rapidly, thus reducing the cost and time required for offsite oil sample analysis. System benefits include reduced oil use, fewer catastrophic failures in expensive mining equipment, and reduced maintenance downtime.

OIT Contact: **Arlene Anderson**

Petroleum

◆ Advanced Fluid Catalytic Cracker *(FCC)* Model

The goal of this OIT-supported effort is to develop and validate a three-dimensional (3-D) integrated model that can be used as a design tool for modifying fluid catalytic cracking (FCC) hardware and processes. This tool will be used to optimize operating conditions for specific feedstocks to increase product yields and energy efficiency and to reduce environmental impacts. This tool has the potential to increase the yields of FCC gasoline and alkylate by 3% to 7% while reducing carbon dioxide SO_X and NO_X emissions.

OIT Contact: **James Quinn**

◆ Advanced Membrane Devices for Natural Gas Cleaning

The goal of this effort is to develop membranes for upgrading subquality natural gas. Semi-permeable polymeric membranes are used that preferably permeate carbon dioxide and water and leave methane gas behind. By using such a membrane device, low-grade natural gas, with high CO_2 and water contents, can be made into a pipeline-grade gas for domestic and industrial consumption.

OIT Contact: **James Quinn**

◆ Catalytic Cracking Demonstration Plant

A new low-profile, fluid catalytic cracking process is being demonstrated that will increase yields and lower costs for any size of refining operation. This new process will also incorporate advances such as a short residence time, rapid disengaging, a high catalyst-to-oil ratio, and the matching of feed reactivity to catalyst activity.

OIT Contact: **Lisa Barnett**

Petroleum
(continued)

◆ Distillation Column Flooding Predictor

A new control technology provides a more accurate estimate of distillation column flooding. The patented pattern recognition technology predicts liquid and jet flooding in the petroleum-refining process. The system identifies patterns of transient tower instabilities, which have been discovered to precede tray flooding. Such identification allows the distillation column to be operated closer to the true flood limit, thus increasing the efficiency of the refinery process while avoiding an actual flood event.

OIT Contact: **Lisa Barnett**

◆ Gas Imaging for Advanced Leak Detection

This project addresses the development and sufficient miniaturization of a gas-imaging system for increased transportability and usability by one person. The small size allows the use of newly developed laser materials and a high-power fiber amplifier. This improved technique can locate hydrocarbon leaks from process piping components by optical imaging of gas plumes.

OIT Contact: **James Quinn**

◆ Petroleum Fouling Mitigation

Fouling is a deposit buildup in refinery process units that impedes heat transfer, increases pumping power, and is a leading cause of diminished efficiency and productivity in refineries. This project developed a threshold-fouling model and fouling test units for establishing operating procedures to allow refineries to operate equipment below threshold fouling conditions. The refinery industry will use these tools to determine the root cause of fouling and to evaluate cost-effective mitigation techniques. Fouling mitigation provides the basis for the condition-based maintenance of heat-exchange equipment.

OIT Contact: **James Quinn**

Petroleum
(continued)

◆ Pulsed Laser Imager for Detecting Hydrocarbon and VOC Emissions

A new hydrocarbon detection device, the pulsed laser imager, uses the principles of infrared spectroscopy to locate and measure the extent of hydrocarbon leaks and emissions of volatile organic compounds (VOCs). The imager's main advantage over its competitors is its remote-sensing feature that does not require an air sample. The imager detects hydrocarbon leaks from a safe distance by analyzing the electromagnetic spectra of the compounds. Both the short- and long-range versions of the pulsed laser imager are flexible, sensitive, accurate, and intrinsically safe and provide a cost-effective solution to hydrocarbon detection.

OIT Contact: **Lisa Barnett**

Steel

◆ Automated Steel Cleanliness Tool *(ASCAT)*

The development and use of this technology will allow steel producers to evaluate the quality of steel during production. The technology consists of a rapid, near-real-time analysis tool that can locate, size, and identify critical defects. The technology has the potential to be used in the production of about 5 million tons of steel/year for critical applications. The tool will be demonstrated as part of the steel production process in two steel mills.

OIT Contact: **Isaac Chan**

◆ Cost-Effective, Energy-Efficient Steel Framing

The construction industry has used steel framing in residential construction for several years. However, designs for minimal energy code compliance have not always been cost-effective or practical. This project focuses on overcoming the major performance and cost barriers that prevent many builders from using steel framing. The project considers thermal performance and installed cost to determine designs for steel-framed residential and light commercial construction that are energy-efficient and meet applicable building codes.

OIT Contact: **Isaac Chan**

◆ Electrochemical Dezincing of Steel Scrap

The technology separates steel scrap into dezinced steel scrap and metallic zinc. The removal of zinc from steel scrap increases the recyclability of the underlying steel and reduces steelmaking dust and eliminates zinc from wastewater streams.

OIT Contact: **Gobind Jagtiani**

Steel
(continued)

◆ Enhancing the Operation of Highly Varying Loads in Steel Mills

This project is developing and refining algorithms to better optimize the operation of electric arc furnace melting for steel production. The resulting control method will optimize the power and time utilization factors in the electric arc furnace process, which will help reduce energy consumption and, through increased system efficiency, reduce greenhouse gas emissions created by the arc furnaces and other devices such as rolling mills. Active control of these processes will also increase electric quality and reliability for steel mills and other customers on the electric grid.

OIT Contact: **Fred Hart**

◆ Hot Strip Mill Transfer Bar Edge Heating

A new edge heater technology is being demonstrated that reheats the transfer bar edges of steel slabs during processing. This new system addresses the problem of edge-related defects that occur during the production of sheet steel coils. A higher quality product results from an evenly heated steel slab. Less energy is needed and fewer emissions result from using this new system.

OIT Contact: **Lisa Barnett**

◆ Improved Surface Quality of Exposed Automotive Sheet Steels

Surface quality in exposed applications (i.e., visible to the final consumer) represents an enormous economic, technical, and operating issue for steel producers. The goal of this project is to develop a methodology to better quantify the geometry of surface imperfections and to understand their evolution during forming and painting. The ability to quantitatively assess the severity of specific surface features is expected to lead to more objective inspection and acceptance criteria. The resulting benefits include improved application rates and reduced rejection of steel sheet, leading to energy savings and environmental benefits.

OIT Contact: **Isaac Chan**

Steel
(continued)

◆ Intelligent Systems for Induction Hardening

A multi-disciplinary team is working to optimize the induction hardening process. Current research efforts are focusing on: 1) developing a rigorous computational model of the process, including a fundamental understanding of materials/process interaction behavior during the induction heating and hardening processes; 2) developing science-based sensors and closed-loop control algorithms applicable to a broad range of steels, processes and component geometries; and 3) using these tools to develop steel components with optimized strength-to-weight ratios.

OIT Contact: **Isaac Chan**

◆ Laser-Assisted Arc Welding

Applying this new process to steel welding will meet the needs for a new joining technology. The benefits of combining laser- and arc-welding processes will ease the current requirement for precise fit when laser welding alone. Using filler metals in the arc-welding component of the process will result in greater flexibility in the choice of materials that are joined. The process could easily be applied to nonlinear joint geometries. This process will increase the welding throughput and productivity over either laser or arc welding alone.

OIT Contact: **Isaac Chan**

◆ Magnetic Gate System for Molten Metal Flow Control

This project is developing an electromagnetic flow control unit that improves the quality and productivity of the continuous casting process. The dc axisymmetric flow control device has the potential to overcome the disadvantages of high-frequency, high-power electric currents that have been tried previously. The device's configuration allows it to be used around conventional ceramic pouring tubes.

OIT Contact: **Gobind Jagtiani**

Steel
(continued)

◆ Method of Making Steel Strapping and Strip

A new continuous process has been developed that produces high quality steel strapping and strip from rod stock produced from scrap steel. The process yields a higher quality, less expensive, product while increasing the amount of recycled steel in the finished product. The continuous process has lower processing and capital costs than the conventional production method while increasing the strength of the final product.

OIT Contact: **Lisa Barnett**

◆ Microstructure Engineering for Hot Strip Mills

Computer models aimed at improving the hot rolling process are linking mechanical properties to the process parameters of the mill. These models help predict mechanical properties on-line of A-36 carbon steel as well as DQSK, HSLA-V, and HSLA-Nb grade steels. They will allow steel companies to optimize their hot rolling practices, particularly those involving cooling and coiling. In addition to enhancing output and quality, they will reduce the time and cost of developing new grades of steel by allowing off-line experimentation.

OIT Contact: **Isaac Chan**

◆ Nickel Aluminide Radiant Heater

Nickel aluminide radiant heaters benefit from the unique metallurgical properties of nickel aluminide. These properties result from the ordered crystal structure of nickel aluminide and the aluminum content contributing to the formation of a protective aluminum oxide film on the surface of the heaters at high temperature. When applied to radiant heaters, these properties result in oxidation resistance, carburization resistance, and increased high-temperature creep strength. The nickel aluminide radiant heaters offer increased life and better reliability over conventional heaters.

OIT Contact: **Charles Sorrell**

Steel
(continued)

◆ Optical Sensor for Post-Combustion Control in Electric Arc Furnace Steelmaking

This project is developing an optical sensor for electric arc furnace steelmaking based on measuring off-gas temperature and carbon monoxide, carbon dioxide, and water vapor concentrations. The remote-sensing optical instrument is based on tunable infrared-laser technology and will provide input signals for control and optimization of oxygen use and post-combustion emissions. This new technology will also address needs for improving energy use and developing automated process controls.

OIT Contact: **Isaac Chan**

◆ Oscillating Combustion

Oscillating combustion creates successive fuel-rich and fuel-lean zones within the flame. This technology reduces the formation of NO_X and increases the heat transfer from the flame to the load. Oscillating combustion is easily retrofitted to existing burners since no modifications to the burner or the furnace are necessary. This technology is currently being tested in two demonstrations.

OIT Contact: **Gideon Varga**

◆ Plant Trial of Non-Chromium Passivation Techniques for Electrolytic Tin Plate

Three previously developed nonchromium passivation treatments for electrolytic tin plate are being compared in a plant trial to determine their viability. These new techniques will replace the existing cathodic dichromate treatment method that is facing environmental use restrictions. In addition, continued use of chromate treating solutions will result in ever-increasing operating costs.

OIT Contact: **Isaac Chan**

◆ Processing Electric Arc Furnace *(EAF)* Dust into Salable Chemical Products

This unique technology will hydro-metallurgically process EAF dust into saleable products. EAF dust is oxidized and digested in acid and then treated by a series of individual steps to isolate and retrieve individual components of the dust.

OIT Contact: **Lisa Barnett**

Steel
(continued)

◆ Regeneration of Hydrochloric Acid Pickling Liquors

The Pickliq® hydrochloric acid regeneration system is an innovative method of regenerating spent hydrochloric acid from steel pickling. Conventional pickling technology generates 1.5 billion gallons of spent pickle liquor nationwide each year, resulting in costly and energy-intensive handling, treatment, and disposal. This new technology eliminates the disposal problem, significantly reducing operating, environmental, and capital costs. The process uses sulfuric acid to restore hydrochloric acid for reuse.

OIT Contact: **Lisa Barnett**

◆ Tunable Diode Laser Spectroscopy for Basic Oxygen Furnaces

This technology uses laser-based sensors to measure the temperature and composition of off-gases such as CO_2 and CO_2 emitted by basic oxygen furnaces. These sensors will provide an early and direct indicator of when the steel-making process is complete, allow real-time process control, and result in optimal energy use in the furnace. The process uses an infrared laser beam fired across the mouth of the vessel to a spectrometer that detects molecular interference with the beam. The instantaneous analysis of CO_2, CO_2, and water in the gases indicates the carbon level of the bath with a high degree of accuracy.

OIT Contact: **Isaac Chan**

Crosscutting Technologies

◆ Advanced Turbine System

Work on the advanced turbine system (ATS) has been re-focused from the development of an advanced industrial gas turbine towards technology integration into the existing product lines. Key technologies associated with lean premix combustion, advanced material systems, and mechanical system enhancements have been identified for potential product integration that will contribute to reduced emissions, lower operating costs and improved durability.

OIT Contact: **Fred Hart**

◆ Advanced Weld Overlay Alloys

A new advanced weld overlay alloy uses pure aluminum wire to make welds on carbon steel or nickel-based alloy substrates. Welding with pure aluminum wire results in a weld overlay deposit with typical aluminum content from 8% to 10%. Such a weld overlay offers a unique combination of oxidation, carburization, and corrosion resistance. This technology can be used in weld overlays for corrosion resistance in basic oxygen furnace hoods used in steelmaking. Various types of alloys are also being considered for that application.

OIT Contact: **Charles Sorrell**

◆ Atmosphere Recovery and Regeneration in Heat-Treating Operations

High-temperature furnace processes used in manufacturing (e.g., heat treating, brazing, and sintering) typically maintain inert gas "atmospheres" over the process. This new technology recovers, cleans, and reuses over 90% of the furnace-atmosphere gas.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

◆ Catalytic Combustion

Low-emission combustion technologies are being developed for industrial gas turbines for use in on-site power generation and cogeneration. These technologies offer flameless combustion that essentially eliminates toxic emissions. The catalyst within the flameless combustion system limits the temperature in the combustor to below the temperature where nitrogen oxides (NO_X) are created. Emission levels will be reduced to less than 5 parts per million (ppm) NO_X and less than 10 ppm carbon monoxide.

OIT Contact: **Bob Gemmer**

◆ Chromium Tungsten Alloys for Use as Reaction Vessels

Chromium-tungsten alloys are a new class of steels having the unique properties of strength, toughness, and stability when subjected to thermal cycling. These properties are a function of the alloy's microstructure, which results in highly favorable material properties. Chromium-tungsten applications include reaction vessels where significant reductions in plate thickness (by up to one-half) are expected and heat-transfer tubing applications where thinner-walled tubes will significantly improve heat transfer.

OIT Contact: **Charles Sorrell**

◆ Continuous Fiber Ceramic Composite *(CFCC)*: Burner Screens

New CFCC reverberatory screens can improve the efficiency of natural gas burners in industrial applications, such as paper or paint drying, metal treating, and glass forming. These screens act as a secondary source of radiation, increasing the radiant output by greater than 50%. Test screens have passed over 10,000 hours and 15,000 thermal cycles on an actual radiant burner test rig.

OIT Contact: **Charles Sorrell**

Crosscutting Technologies
(continued)

◆ Continuous Fiber Ceramic Composite *(CFCC)*: Hot Gas Filters

Hot-gas filters remove fine coal-ash particles in pressurized fluidized bed combustion (PFBC) systems and coal-gasification systems. The porous closed-end tube filter concept and flexible-fabrication method results in a composite-based filter with improved strength and toughness compared to monolithic filter materials. The process has resulted in improved performance at reduced costs. The market for hot-gas filters is closely linked to the success of advanced coal-based power systems, such as PFBC and integrated gasification combined cycle plants.

OIT Contact: **Charles Sorrell**

◆ Continuous Fiber Ceramic Composite *(CFCC)*: Immersion Tubes

Tubular heating elements made of CFCCs are being developed for use in holding furnaces at aluminum casting facilities to keep the hot aluminum molten. The CFCC tubes are extremely tough and durable and can be immersed in the metal rather than suspended above it. This increases efficiency, allows for more uniform heating, reduces the potential for contamination, and results in less down time when compared to the use of monolithic ceramic tubes. The CFCC tubes have survived over 1,000 hours and 31 cycles in a single-tube aluminum melter.

OIT Contact: **Charles Sorrell**

◆ Development of a Composite-Reinforced Aluminum Conductor

The use of composite materials in utility transmission and distribution lines promises substantial, long-term cost and weight benefits. This project is to develop an automated, high-throughput manufacturing method capable of producing the composite-reinforced aluminum conductor reliably and at a cost competitive with conventional conductors.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

◆ Electronic Refrigerant Leak Detector

Heating, ventilation, and air conditioning technicians can detect refrigerant leaks with this hand-held device, which consists of a novel sensor with an engineered thin film and a silicon chip. The sensor features low manufacturing cost and low power requirements. The electronic component embodies a state-of-the-art circuit that has low noise and microcontrolled power. The sensor's proprietary platform can be expanded to detect and monitor other gases such as nitrogen dioxide, chlorine, and ammonia.

OIT Contact: **Lisa Barnett**

◆ Energy-Conserving Tool for Combustion-Dependent Industries

A portable, low-cost, and energy-efficient multigas analyzer that combines infrared spectroscopy with advanced electronics and software is being demonstrated. This system provides continuous emissions monitoring and on-line feedback for combustion tuning of boilers and combustion turbines. The system continuously measures pollutants that are not usually monitored such as formaldehyde and ammonia.

OIT Contact: **Lisa Barnett**

◆ Fabrication and Testing of a Prototype Ceramic Furnace Coil

Conventional metal furnace coils used in the manufacture of ethylene are hampered by temperature limitations and require frequent maintenance to remove coke that builds up inside the metal furnace tubes. Silicon carbide ceramic tubes last two to three times longer than metal-alloy tubes and allow chemicals to be processed at significantly higher temperatures with very low levels of coke deposition. A new process uses microwave and radiant-heating technologies to join pairs of silicon carbide tubes to create long enough coils to be used in high-temperature furnaces.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

Forced Internal Recirculation Burner
In developmental testing at 20 MMBtu/hr on an industrial boiler, this new burner routinely realized 6 parts per million NO_X. This exceptionally low level was reached using a combination of air staging, premixed combustion, enhanced heat transfer to load and forced internal re-circulation of combustion products within the boiler's combustion zone. Further reductions of NO_X are believed possible. The burner will be applicable to a wide range of boilers in the 50-100 MM Btu/hr range.

OIT Contact: **Gideon Varga**

High-Energy Flux Processing
High-energy flux processing is being successfully developed using high-density infrared heating. Infrared heating is a clean, non-contact process that ramps to full power in milliseconds and shuts down instantaneously. A number of applications of infrared heating are being pursued including joining, preheating, coating consolidation, stress relieving, and composite fabrication. Infrared processes are energy-efficient, effective, safe, and environmentally friendly, and can bring significant cost savings.

OIT Contact: **Charles Sorrell**

High-Energy Infrared Surface Treatment and Coatings
High-energy infrared heating has many advantages over other heating techniques. It is an inherently clean, noncontact heating method; and it has a rapid response to energy fluxes, rapid power level changes, rapid cooling rates, and controllable temperature-gradient processing with flux densities up to 3.5 kW/cm2. This technology is currently being used to produce wear- and corrosive-resistant coatings on various surfaces, and research is being conducted into coatings for aluminum dies used in the automotive industry.

OIT Contact: **Charles Sorrell**

Crosscutting Technologies
(continued)

High-Temperature, Corrosive-Resistant Recuperator
A newly developed ceramic coating is being demonstrated on a furnace recuperator. The use of recuperators in corrosive environments will greatly reduce the energy required for furnaces. The corrosion-resistant coating will significantly increase the operational life of recuperators resulting in economic savings to industry.

OIT Contact: **Lisa Barnett**

High Temperature Refractory Ceramic
A new castable refractory liner material to be used in high temperatures has been developed. The capabilities of this new ceramic liner will be a 200°C improvement in maximum allowable operating temperatures, an operating life extension of five times, and additional cost savings in installation.

OIT Contact: **Lisa Barnett**

Insert Drill Having Three or More Flutes
A new drill concept uses a three-fluted design to lower horsepower requirements by allowing smaller inserts and producing smaller chips. For through-hole drilling, a slug is not produced as the drill exits the metal. This results in a cleaner hole that does not require secondary cleaning operations.

OIT Contact: **Lisa Barnett**

In-Situ, Real Time Measurement of Melt Constituents
A probe is being developed that uses laser-induced breakdown spectroscopy to determine the elemental constituents in an aluminum, glass, and steel melt. This probe will measure continuously and in-situ at any point in the melt, thus providing real-time data, both spatially and temporally. This technology will improve product quality, increase furnace production, reduce energy use, and allow continuous furnace operation.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

◆ Intelligent Extruder
The intelligent extruder development is primarily targeted to the extruded and molded plastics industry. The intelligent control of extruder operation is becoming critically important as plastic manufacturers face significant yield losses, up to 20%, from off-line and delayed measurement of key process variables such as viscosity and color. The model-based inferential measurement system being developed provides real-time feedback so that production can be quickly controlled and kept within tolerance limits.

OIT Contact: **Gideon Varga**

◆ Iron Chromium Alloys for Use in Corrosive Environments
A new alloy (Fe-35Cr-2.5%Si) has significant potential for applications in the glass and chemical industries. The alloy is based on a sufficient level of chromium to resist aqueous corrosion and the required silicon content for the formation of SiO2 on the surface for high-temperature oxidation resistance. This alloy is castable by conventional commercially available processes; it can be hot-formed (forged, rolled, or extruded); has limited cold formability and can be welded in thin sections without pre- and post-weld heat treatments. The alloy has been recently formed into a prototype for testing as a water cooler for refractories used in a glass-melting furnace.

OIT Contact: **Charles Sorrell**

◆ Melt De-sulfurization
A new process that efficiently removes sulfur from metals at low cost could reduce the cost of electricity production. Nickel-based superalloys, used in high-strength blades for advanced combustion gas turbines, are strongly affected by sulfur in the metal, even in small amounts. (Sulfur causes the protective oxide to flake off). This new de-sulfurization process is applied to the metal alloy in the molten state, resulting in significant reduction of sulfur levels at a low cost. Longer blade life will lead to lower electricity costs.

OIT Contact: **Charles Sorrell**

Crosscutting Technologies
(continued)

◆ Membrane Technology to Remove Entrapped Air from Ammonia Refrigeration Systems
A new membrane module for separating gases was developed and tested to determine process parameters and optimum operating conditions. This membrane has the potential to be an effective component in an ammonia-separation and air-purge system either as a stand-alone membrane technology or as an enhancement to existing purge systems.

OIT Contact: **Lisa Barnett**

◆ Miniature, Inexpensive, Amperometric Oxygen Sensor
A new sensor to measure oxygen partial pressure in boiler exhaust gas has been developed. The new amperometric sensor, which is a multi-layer ceramic capacitor, is ideal for inexpensive mass production. The large reduction in cost of the sensor will economically allow commercial and residential systems to be more closely controlled, thus saving energy.

OIT Contact: **Lisa Barnett**

◆ Mobile Zone Optimized Control System for Ultra-Efficient Surface-Coating Operations
This new spray booth technology has the potential to greatly reduce the amount of energy needed to heat and cool ventilation air during surface coating operations. This system separates the human painter from the objects being painted by housing the painter in a separate, mobile cab during spray coating operations. The cab is flushed with treated makeup air, while the rest of the spray booth uses recirculated air. The operator in the cab is protected from fire and explosion risks and does not need to wear protective gear.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

Nickel Aluminide Forging Dies
Nickel aluminide, because of its ordered crystal structure, has increased yield strength with increasing temperature. The unique strength/temperature relationship of nickel aluminide is ideal for use in forging dies. These new dies exhibit longer life, improved forging dimensional stability, and better productivity through less waste and less time spent changing dies.

OIT Contact: **Charles Sorrell**

Nickel-Based Superalloy with Improved Weldability and Oxidation Resistance
Testing of a new nickel-based superalloy process is underway. This process enriches turbine blades with palladium, which dramatically increases equipment life. This system is expected to reduce the amount of aluminum required for corrosion resistance, resulting in improved weldability.

OIT Contact: **Lisa Barnett**

On-Line Laser-Ultrasonic Measurement System
On-line laser-based ultrasonic measurement of thickness and eccentricity will improve productivity of seamless mechanic steel tubing by 30% to 50% and will correspondingly reduce energy consumption and the emission of pollutants. An estimated minimum total cost savings of $234 million/year would be realized if the laser-ultrasonic technology were applied throughout all U.S. seamless tube and pipe mills to control the piercing process and reduce the safety tolerance associated with eccentricity.

OIT Contact: **Gideon Varga**

Particulate Ejection Coal Fired Turbine
A redesigned prototype of a new medialess dynamic filter is being tested for operation at the high temperatures typically found in the coal-fired electric utility industry. If successful, this technology will eliminate or reduce the need for porous ceramic candle filters for hot gas filtration in coal-fired gas turbines; will operate at higher temperatures than current ceramic materials, thus improving energy efficiency; and will eliminate or reduce periodic landfilling of the spent ceramic candles.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

Rotary Burner
A new rotary burner that provides ultra-low combustion emissions along with significant fuel and electricity savings has been developed and field-tested. The novel technology uses a process that allows for expansion of pressure energy in a rotary burner, meaning that combustion air needs can be satisfied and inherently coupled to match the fuel demand to ensure the desired air-to-fuel ratio.

OIT Contact: **Lisa Barnett**

Self-Dressing Resistance Welding Electrode
The project is designed to produce an electrode from a unique metal-matrix composite material that employs a ceramic substrate as the load-bearing element and a metal matrix as the conduit for the electric current flow. The project will be carried out in four separate tasks, consisting of material selection, design development and optimization, fabrication and model verification, and performance test and evaluation.

OIT Contact: **Lisa Barnett**

Sensing and Control of Cupola Furnaces
This project is developing an intelligent, integrated industrial process sensing and control system to optimize the performance of cupola furnaces. This system regulates the melt rate, temperature, and iron composition of the furnace. Successful control of furnace variables will increase energy efficiency, furnace yield, and productivity and will reduce environmental emissions.

OIT Contact: **Gideon Varga**

Structural Monitoring System Using Fiber Optics
A new system uses a continuous fiber optic cable to monitor the behavior of a structure. Potential applications include monitoring strain levels in nuclear and fossil fuel power plant structures; sag and strain in electric powerlines; and strain of oil and gas pipelines, oil tankers, storage tanks, and dams.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

◆ Thermal Imaging Control of High Temperature Furnaces

The near-infrared thermal imaging system fine-tunes the main furnace controller for improved combustion performance. The system uses multiple infrared wavelengths combined with a periscope probe to map the full field of combustion space during furnace operation. Control algorithms minimize differences between measured field temperatures and temperature set points and send output signals to the main furnace combustion control. Optimizing the combustion process has been shown to decrease the total fuel use by at least 5%, with a corresponding decrease in airborne emissions.

OIT Contact: **Gideon Varga**

◆ Thermobarrier Coatings

Thermal barrier coatings for industrial gas-turbine components are critical for higher temperature operation and longer lifetimes. Current coatings do not last over 8,000 hours, and improvements are needed to achieve 25,000 hours in industrial applications and corrosion resistance. Coated components include combustor liners, blades, and vanes.

OIT Contact: **Charles Sorrell**

◆ Thermoelectric Generator for Diesel Engines

This new technology generates electric energy from waste heat and has many applications in the power industry, as well as in the Chemical and Petroleum industries. One possible application is as an array on the exhaust of the gas turbine to increase efficiency. Heavy earth moving equipment for mining presents another potential application.

OIT Contact: **Lisa Barnett**

Crosscutting Technologies
(continued)

◆ Tough-Coated Hard Powders *(TCHP)*

This new class of tool and die materials is being developed to replace tungsten carbide and cobalt mixes in producing hard products. Tools made with tough-coated hard powders do not require an external coating because hard and tough phases are already dispersed throughout the tool, resulting in a continuously renewed wear surface within a tough substrate. This surface will greatly extend tool life, reducing manufacturing costs.

OIT Contact: **Lisa Barnett**

◆ Tribopolymerizatiom as an Anti-Wear Mechanism

Tribopolymerization is an advanced technology that uses molecules called monomers to create perpetually renewing films directly on surfaces that require lubrication, such as ceramic or alloy steel. Unlike the action of surface treatments of coatings, which wear away, these protective polymeric films form continuously in critical areas of boundary lubrication and wear. The films efficiently form in localized areas where the greatest amount of wear occurs, reducing wear and friction, and saving energy in the process.

OIT Contact: **Lisa Barnett**

◆ Ultra-Low NO_X Premixed Industrial Burner

Combustion-process-dependent industries are faced with more stringent environmental regulations to reduce NO_X emissions. Some states require NO_X emission reductions as great as 90% for the chemicals and refining industries. The ultra-low NO_X burner uses lean premixed combustion gases and low swirl flow of combustion gases to achieve NO_X emission levels <10 ppm (a reduction of 80% to 90%). This burner concept can be applied to a wide range of combustion systems, including furnace and boiler applications, gas turbines, and chemicals and refining industry liquid process heaters. The burner can be operated with natural gas, biomass gas, and prevaporized liquid fuels. The burner is scalable and simple in design with no need for costly materials for manufacturing and installation.

OIT Contact: **Robert Gemmer**

Crosscutting Technologies
(continued)

◆ Wear Resistant Composite Structure of Vitreous Carbon Containing Convoluted Fibers

A novel method makes a composite material consisting of a vitreous carbon matrix containing convoluted fibers. The resulting product has better wear resistance, lower coefficient of friction and higher electrical conductivity than competing materials. The material is being developed for use in cable and third rail electric transportation systems, such as light rail.

OIT Contact: **Lisa Barnett**

Other Industries

◆ Clean Energy From Municipal Solid Waste

The innovative and unique SlurryCarb process completely reduces MSW to a liquid form, and then treats it in a heated anaerobic pressure unit to rearrange the slurry molecularly. This step produces an homogeneous, clean fuel with an energy density 400% greater than untreated material. The high-energy renewable "E-Fuel" can be injected with less than 20% excess air into a pulverized coal burner and is cleaner to burn than most coal.

OIT Contact: **Lisa Barnett**

◆ Coal-Fired Air Turbine *(CAT)* Cycle Plant

This new system, which uses a CAT-cycle to generate electricity using coal, compressed air, and steam, has lower capital-investment costs than the competing cogeneration systems. In addition, the CAT-cycle plant minimizes pollution by using a combustion system with a bed of circulating fluids. Currently, there is interest in biomass as a fuel for air turbines rather than coal. This favors scattered small plants, to use the biomass gathered locally from areas surrounding the power plant. The air turbine concept is better suited to small size plants than its main competitor, the steam turbine plant.

OIT Contact: **Lisa Barnett**

◆ Deep-Discharge Zinc-Bromine Battery Module

A new zinc-bromine battery is being demonstrated that increases load-leveling efficiency and offers longer cycle life with less weight than conventional lead-acid batteries. This new battery is applicable to electric utilities and industrial companies. The modular construction allows for sizing and portability of the system to suit multiple applications and needs. This technology allows customers to purchase lower-cost power or generate on-site power and then use it for reducing peak-power purchases.

OIT Contact: **Lisa Barnett**

Other Industries
(continued)

Electrolytic Regeneration of Acid Cupric Chloride Printed Circuit Board Etchant

The Oxley Research process is an electrochemical process that regenerates spent chemicals formed through etchant action in producing etched printed circuit boards. The process uses a unique arrangement of one anode and two separately controlled cathodes acting electrolytically on the etchant solution. Environmental concerns obviously derive from the need to transport and use hazardous chemicals and excess etchant. Cost benefits from this process will come from two sources: avoidance of transportation, chemical, and other costs associated with chemical regeneration and excess etchant disposal, and a direct credit derived from the sale of copper.

OIT Contact: **Lisa Barnett**

Environmental Tensometer

The invention is used for high temperature testing of the tensile strength and related physical properties of the single-filament refractory fibers under varying atmospheric conditions, new small composites, and thin membranes for oxygen separation applications. The system integrates a furnace, testing unit, gas-handling system, vacuum system, and PC-based software.

OIT Contact: **Lisa Barnett**

Float Zone Silicon Sheet Growth

This innovative technology consists of a process to develop crystalline silicon sheet from a polycrystalline silicon surface. Its primary goal is the efficient, low-cost production of high-quality crystal silicon sheet for the electronics industry. Development of this process will provide several important benefits, such as high production rates, good dimensional control, improved crystal quality, and remarkable purity comparable to the source material.

OIT Contact: **Lisa Barnett**

Other Industries
(continued)

Gas Turbine Cooling Improvement

Despite their relative simplicity, turbine engines have drawbacks that have prevented their widespread use. For example, turbine blades burn up if operated at the temperature required to be as efficient as a modern reciprocating engine; thus, they must be operated at lower temperatures, making them less efficient. A new innovation in turbine engines is being tested that uses high-pressure air flowing from the compressor through the hollow turbine blades, thus cooling them. This cooling allows the turbine inlet gas temperature to be increased, improving engine efficiency by 8% to 15%. Such efficiencies could allow gas turbines to compete with much bulkier diesel and gasoline engines on the basis of fuel economy.

OIT Contact: **Lisa Barnett**

High-Intensity Silicon Vertical Multi-Junction Solar Cells

This new solar cell, now being demonstrated, combines higher voltage and lower current operation to create highly efficient, concentrated solar power conversion. The immediate application is for bulk electric power generation for large-scale (>100-kW) central power stations in sunny, semi-arid regions of the world. The simple design of the new cell results in lower manufacturing costs and robust reliability compared with existing concentrating cells.

OIT Contact: **Lisa Barnett**

Hydrodyne Process for Tenderizing Meat

The hydrodyne process offers a unique way of tenderizing meat, particularly tougher meat with less fat. The innovative new technology reduces beef tenderization time from weeks to a fraction of a second by using hydrodynamic shock waves, the process can increase beef tenderness in tougher meat cuts by as much as 72% without changing natural appearance, texture, or flavor.

OIT Contact: **Lisa Barnett**

Other Industries
(continued)

◆ Polymer-Dispersed Ferroelectric Smectic-C* Display Technology

With this technology, rugged devices can be fabricated, even on plastic substrates. Beam steering devices, such as electrically controllable one- and two-dimensional optical gratings, have been fabricated. Using a photomask during phase separation, this technology has also been used to construct a microlens array of diameter less than 400 micrometers and with a natural focal length ranging from 2 mm to 5 cm. With the help of an electric field, the focal length of the microlenses can be increased to infinity. This does not appear to be possible with any other technology with such a simple fabrication method.

OIT Contact: **Lisa Barnett**

◆ Precision Forging II

Two technologies are being developed under this research program: the forging advisor and alternatives to phoscoating. The forging advisor is a manufacturing process selection system that compares forging against casting, machining, and laser-engineered net shape processes and a design advisor that provides input on best practices for design forgeable parts. Due to the potential legislative restrictions on the use of phosphate coatings as a lubricant for metal-forming processes, alternative synthetic clean lubricants are being assessed in terms of performance and cost.

OIT Contact: **Charles Sorrell**

◆ Single Device Equivalent to CMOS

A new process for producing an inverting single metal oxide semi-conductor (MOS), which operates like a conventional Complimentary Metal Oxide Semiconductor (CMOS) requires fewer fabrication steps than in conventional processing. This leads to greater yields per batch and saves energy.

OIT Contact: **Lisa Barnett**

Other Industries
(continued)

◆ SO_3 Cleaning Process in Semiconductor Manufacturing

A new process is being demonstrated that removes photoresist from semiconductor wafers by exposing the wafers to SO_3 gas followed by a deionized water rinse. Hardened photoresist must be thoroughly cleaned from very small crevices on the wafer at various stages in the manufacturing process. This process is anticipated to substantially replace damaging dry stripping and wet stripping that produces hazardous waste in the semiconductor manufacturing industry.

OIT Contact: **Lisa Barnett**

◆ Thermophotovoltaic Electric Power Generation Using Exhaust Heat

This new technology produces electricity directly from furnace exhaust waste heat by using infrared-sensitive photovoltaic cells. The cells are mounted inside ceramic tubes that are heated in the high-temperature exhaust stream from furnaces in the glass, steel, or metalcasting industries. This technology allows on-site generation of electricity from industrial waste heat.

OIT Contact: **Lisa Barnett**